Technical Memorandum

Importance of Monitoring for Goal 2 of the Comprehensive Assessment and Monitoring Program (CAMP)

Prepared for

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Importance of Monitoring for Goal Two of the Comprehensive Assessment and Monitoring Program (CAMP)

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Summary

To date, results of juvenile salmonid monitoring have limited value to the CAMP goal of assessing the effectiveness of 3406(b) categories of actions on achieving Andromous Fish Restoration Program (AFRP) natural production goals. To consistently and reliably translate monitoring results of restoration actions, so they are comparable to measures of juvenile production and allow assessment of the effectiveness of categories of restoration actions, requires a systematic monitoring program that can be implemented for all restoration actions. Lacking site-specific restoration monitoring data, CAMP will be unable to assess which types of actions are most effective for restoring anadromous fish populations, and CAMP Goal 2 will not be achieved. If CAMP Goal 2 is not achieved, a valuable opportunity to understand which actions are most effective and cost efficient in accomplishing the primary goals of the Central Valley Project Improvement Act (CVPIA), restoring anadromous fish populations, is lost. In turn, the availability of Restoration Fund monies for implementing restoration actions may be reduced.

Site-specific monitoring results should be designed with the primary goal of evaluating the effectiveness of individual restoration actions. Those results can then be interpreted along with the longer term CAMP juvenile production data to evaluate the effects of restoration action categories and to compare action categories among watersheds.

Background and Purpose

Section 3406(b)(16) of the CVPIA specifies the development of a CAMP to evaluate the effectiveness of actions intended to enhance natural production of anadromous fish in Central Valley rivers and streams. CAMP has two goals:

1. To assess the overall (cumulative) effectiveness of actions implemented pursuant to CVPIA Section 3406(b) in meeting AFRP production targets

2. To assess the relative effectiveness of categories of Section 3406(b) actions (e.g., water management modifications, structural modifications, habitat restoration, and fish screens) toward meeting AFRP production targets

Goal 1 relies on annual production estimates of adult chinook salmon (all races), steelhead trout, striped bass, American shad, white sturgeon, and green sturgeon to assess the overall effectiveness of CVPIA actions.

Goal 2 relies on measures of juvenile chinook salmon production and related biotic and abiotic variables in selected watersheds to assess the relative effectiveness of categories of restoration actions.

This memo discusses the role of monitoring in evaluating the effectiveness of 3406(b) actions under Goal 2 and includes:

- Existing monitoring approaches
- Application of existing monitoring approaches to Goal 2
- Site-specific monitoring strategies
- Approaches for future monitoring under Goal 2

Existing Monitoring Approaches

Goal 2 of CAMP relies on established watershed monitoring programs to estimate juvenile salmonid abundance and site-specific monitoring of individual restoration projects to assess the relative effectiveness of four types of restoration actions:

- Water management modifications
- Structural modifications
- Habitat restorations
- Fish screens

Juvenile salmon abundance is used by AFRP as a measurement of salmon production and survival attributable to AFRP actions. When normalized for the number of adult females, relative changes in numbers of juvenile salmon serve as a primary indicator of habitat conditions in the natal streams. The focus on juvenile salmon avoids the need to account for many variables not related to AFRP actions, including ocean conditions, ocean sport and commercial harvest, habitat conditions and water quality outside of natal streams, in-river sport harvest, and predation and water project operations in the Sacramento-San Joaquin Delta and San Francisco Bay.

The approach has been to combine juvenile outmigrant monitoring for a watershed with estimates of effects of each restoration action on juvenile production to assess the relative effectiveness of action categories in restoring anadromous fish populations.

Rotary screw traps (RSTs) are the primary means to evaluate trends in juvenile salmon abundance. Rotary screw traps do have limitations, such as (1) capturing predominately smaller size juvenile salmon; (2) washing out or becoming miscalibrated in streams subject to large flow fluctuations; and (3) misrepresenting population sizes because of low trap efficiency and high variability. Even with these limitations, RSTs are an effective monitoring tool and can provide a reliable estimate of juvenile production when used consistently over a number of years. Other monitoring methods, such as snorkel and seining surveys, have also been used in conjunction with RSTs to attempt to derive more accurate estimates of juvenile abundance.

Applying Monitoring Results to Goal 2

Juvenile salmonid monitoring funded under CAMP or through other private or public programs has given resource managers increased ability to understand the dynamics of juvenile outmigration and the factors influencing juvenile survival, and provides a qualitative index of whether the sum of restoration actions occurring in a watershed influences juvenile salmonid abundance. To date, results of juvenile salmonid monitoring have limited value to the CAMP goal of assessing the effectiveness of 3406(b) categories of actions on achieving AFRP natural production goals for the following reasons.

- **Lack of standardized monitoring approaches among streams results in variable, noncomparable data.** Trap efficiencies are highly variable within and among watersheds, and many factors influence trap efficiency, such as timing of trap installation relative to fry emergence, duration of trapping, changes in flow velocity, diurnal movement patterns, juvenile life stage, vertical and lateral positioning of the trap in the stream channel; frequency with which the trap is checked; and, in the case of a controlled fish release, distance and position of the release from the RST. The high degree of natural variability within and among watersheds, combined with inconsistencies and differences in methods within and among monitoring programs, makes reliable estimates of trap efficiency problematic. Narrowing the confidence limits on trap efficiency data is critical to developing reliable estimates of juvenile salmonid abundance.

- **Insufficient site-specific data are collected for individual restoration projects.** Many restoration actions have not included juvenile salmonid monitoring. The placement of one or two RSTs in a river is useful for watershed-level monitoring but is inadequate to conduct the type of hypothesis testing necessary to assess the effectiveness of a restoration action on juvenile salmonid abundance.

- **Simultaneous implementation of multiple restoration actions in a watershed and natural variability within a watershed confound data interpretation.** Watershed-level juvenile salmonid monitoring is useful to document progress in eliminating known factors limiting salmon production, but too many influences exist to attribute benefits to a specific restoration action. Ideally, to minimize these confounding influences, evaluation of fish population response to restoration actions would analyze paired treatment and control watersheds, and each restoration action in a watershed would be implemented in isolation. Juvenile production also would be monitored before and after implementing a single type of restoration action.

- **Goal 2 may not be the monitoring objective of existing monitoring programs.** Existing monitoring programs may be using RSTs for qualitative purposes, such as the timing of juvenile salmonid outmigration and characterizing the size class of outmigrating fish. If estimates of trap efficiency are not part of the monitoring objective, the data are not appropriate for use in population estimating.

- **The process for data management continues to be inefficient.** There has been an effort to create a centralized repository for fisheries data as part of the Interagency Ecological Program (IEP) at the Department of Water Resources. Given the sheer volume of data from so many different sources, this arrangement can be cumbersome, and reliable data may not be available in a timely manner. Many data providers do not have the staff and/or resources available to manage and distribute data they collect. A more fluid process for data sharing between data providers and data users would benefit CAMP.

Options

The different approaches available for future monitoring under CAMP Goal 2 have associated benefits and disadvantages.

1. Discontinue Goal 2 Monitoring Programs Under CAMP

   Program and data limitations have impeded the application of existing juvenile salmonid monitoring data toward achieving Goal 2. Unless a standardized, focused monitoring program is implemented, CAMP will continue to be unable to assess which types of ongoing actions are most effective for restoring anadromous fish populations, and CAMP Goal 2 will not be achieved. The current level of juvenile monitoring under CAMP has, however, provided watershed-level information useful for understanding the dynamics of juvenile outmigration, factors influencing juvenile survival, and a qualitative index of assessing whether the sum of restoration actions occurring in a watershed are influencing juvenile salmonid abundance.

   If the current level of juvenile monitoring under CAMP is discontinued, funding can be redirected and used to benefit other CVPIA programs. The disadvantage of terminating juvenile monitoring is that watershed-level data on juvenile abundance will no longer be available, and there will be even less opportunity to understand which restoration actions are most valuable and cost effective in accomplishing CVPIA primary goals. In turn, the availability of Restoration Fund monies likely will be reduced.

2. Continue Watershed-Level Juvenile Chinook Salmon Monitoring

   The advantage of continuing the current level of juvenile production monitoring under CAMP is that it continues to provide information on juvenile production that can be used to qualitatively assess conditions within a watershed. The disadvantage is that the current level of monitoring is insufficient to assess the efficacy of AFRP restoration actions and will not achieve Goal 2. The possibility may exist to use juvenile salmonid monitoring data required as a component of CALFED-funded restoration projects as a compliment to CAMP-funded watershed-level monitoring to better assess Goal 2.

3. Initiate Site-Specific Monitoring of AFRP Restoration Actions

   Assessment of the relative effectiveness of categories of actions is best approached by spatially isolating and monitoring the effects of specific restoration actions in watersheds while also monitoring total juvenile outmigration for the entire watershed. This combination of monitoring juvenile production and assessing the contribution of individual restoration actions to that production provides a measure of the relative contribution of restoration actions to juvenile production. The benefit of conducting site-specific monitoring under CAMP is that it gives agencies that are responsible for meeting Goal 2 the opportunity to establish and implement standardized monitoring approaches that are necessary to collect data meaningful for Goal 2 analyses. It also gives these agencies more control in setting site-specific monitoring objectives and influence over how the data is collected, cataloged, and used. The disadvantage is that it is costly, labor intensive, and may require long-term funding commitments (e.g., greater than 1 year) to collect data sufficient for effectively evaluating the effects of AFRP restoration actions. The concept of site-specific monitoring, including hypothesis testing, performance-based monitoring metrics, and monitoring techniques are presented in Appendix A.

Conclusion

Currently, the CAMP annual report summarizes information on adult escapement and juvenile abundance for target species in CAMP watersheds. In the CAMP Conceptual Plan (USFWS, 1996) and CAMP Implementation Plan (USFWS, 1997), it was anticipated that site-specific monitoring would be included in annual reports. Since 1996, however, site-specific information has been available only sporadically and in a limited number of watersheds, and has not been a large component of reporting. The combination of site-specific juvenile monitoring and watershed-level juvenile monitoring on CAMP watersheds would best meet the intent of Goal 2. These data are also relevant in understanding the cumulative effectiveness of AFRP actions on adult production pursuant to CAMP Goal 1.

APPENDIX A

Site-Specific Monitoring Strategies

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Site-Specific Monitoring Strategies

It is generally accepted by fishery scientists that juvenile abundance, over a sufficient period of time and under a broad range of conditions, is an adequate measure of a stream's ability to produce and sustain salmonids and that adult salmon counts (in-river estimates, hatchery returns, and in-river and ocean harvest estimates) are an adequate measure of total production. Hypothesis-based performance monitoring of restoration actions using these indices is a cost-effective approach to site-specific monitoring.

Juvenile production monitoring for the total watershed, combined with estimates of the effects of each restoration action on juvenile production, provide the best opportunity to assess the relative effectiveness of action categories to restore anadromous fish populations.

Ideally, evaluations of fish population responses to restoration actions would analyze paired treatment and control watersheds. An optimal sampling design would monitor juvenile production in one or more watersheds before and after implementing a single type of restoration action, and compare changes in juvenile abundance in these watersheds with those occurring in suitable control streams. Given the simultaneous implementation of multiple types of restoration actions in a single watershed and the natural variation among watersheds in other variables, implementation of this sampling design is probably impossible to achieve in natural stream systems.

Given these limitations, assessment of the relative effectiveness of categories of actions is best approached by spatially isolating and monitoring the effects of specific restoration actions in watersheds while also monitoring total juvenile outmigration for the entire watershed.

To consistently and reliably translate monitoring results of restoration actions, so they are comparable to measures of juvenile outmigration, requires a carefully designed, systematic monitoring program that can be implemented for all restoration actions. The specific types of data collected for each project in each of the categories of actions should provide consistent results, regardless of where the restoration action is implemented and by whom. Data should be reliably communicated to CAMP so the information may be included in the CAMP annual report, the reporting instrument for assessing the relative effectiveness of the action categories for restoring anadromous fish populations.

The following components should be considered in developing site-specific monitoring for AFRP restoration projects:

- Monitoring templates for the four categories of restoration actions that can be customized for use on individual projects
- Approximate cost estimates to implement each monitoring template, so that sufficient funds are made available for monitoring when projects are approved for funding
- Standard predesigned forms for monitoring results

- Timelines for implementing and reporting the monitoring results

Hypothesis-Based Performance Monitoring

A scientific approach can be used to identify restoration projects and monitor biological objectives that are tied to the AFRP Doubling Goal. To establish a nexus between the action and the pre- and post-implementation monitoring, a hypothesis-based model can be used, such as that adapted from the work of Dr. Michael Healey and the Core Group that advised the CALFED Bay-Delta Program. A detailed discussion of this modeling approach is contained in The Strategic Plan for Ecosystem Restoration (CALFED, 2000). Figure 1 describes this process, and the following text explains the steps.

The objective nests under the over-arching program goal. In the case of the AFRP, the goal is to double the population of anadromous fish. Each restoration objective should contribute to that goal. Restoration objectives may include the addition of spawning gravel to a stream to increase the potential number of redds, increasing instream flow in the spring to stimulate out migration, removing a barrier to facilitate upstream access, or screening a diversion to reduce direct mortality. Each of these examples combines the proposed action with a purpose statement. The hypothesis expresses the cause-and-effect relationship. Using spawning gravel as an example, an hypothesis might be: *redd superimposition reduces the productive capability of salmon populations in stream X. Increasing the area of usable spawning gravel will increase the number of juvenile salmon produced.*

The hypothesis begins to bridge the gap between what we can measure, area of gravel and number of fish, and the cause-and-effect relationship, which is difficult to document in natural systems. A conceptual model converts a hypothesis to an explicit statement or diagrammatic process, which can be tested and compared with alternatives. The conceptual model will help identify the appropriate monitoring criteria to validate or reject the hypothesis.

Figure 2 illustrates a possible conceptual model for a spawning gravel hypothesis: The model is relatively simple but provides a pathway for decisionmaking. The observation of whether the new gravel is used for spawning leads us either to resolution of the problem (e.g., redd superimposition) or a better understanding of factors that limit juvenile production. If juvenile production increases, that parameter could be used in a qualitative "weight of evidence" determination as to whether AFRP actions are effective in achieving the doubling goal.

If monitoring of the action falsifies the hypothesis, it would trigger a series of steps to further define the problem statement and/or the hypothesis. These feedback loops are the essence of adaptive management. A series of successfully tested conceptual models could provide a comparison among categories of actions.

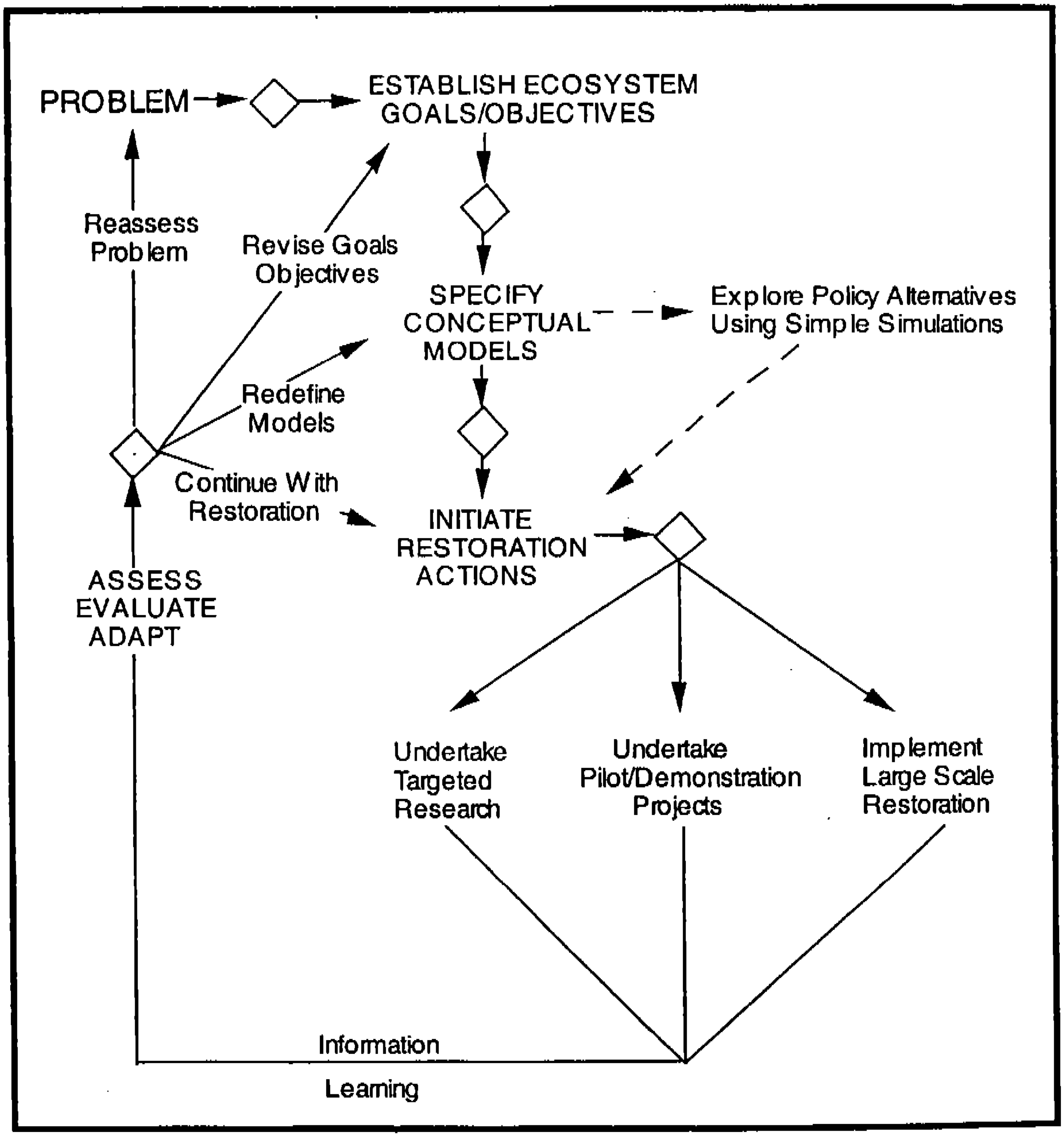

FIGURE 1
Diagram of the Adaptive Management Process

Source: CALFED Bay-Delta Program
Ecosystem Restoration Program Plan
Strategic Plan for Ecosystem Restoration
Final Programmatic EIS/EIR Technical Appendix, July 2000

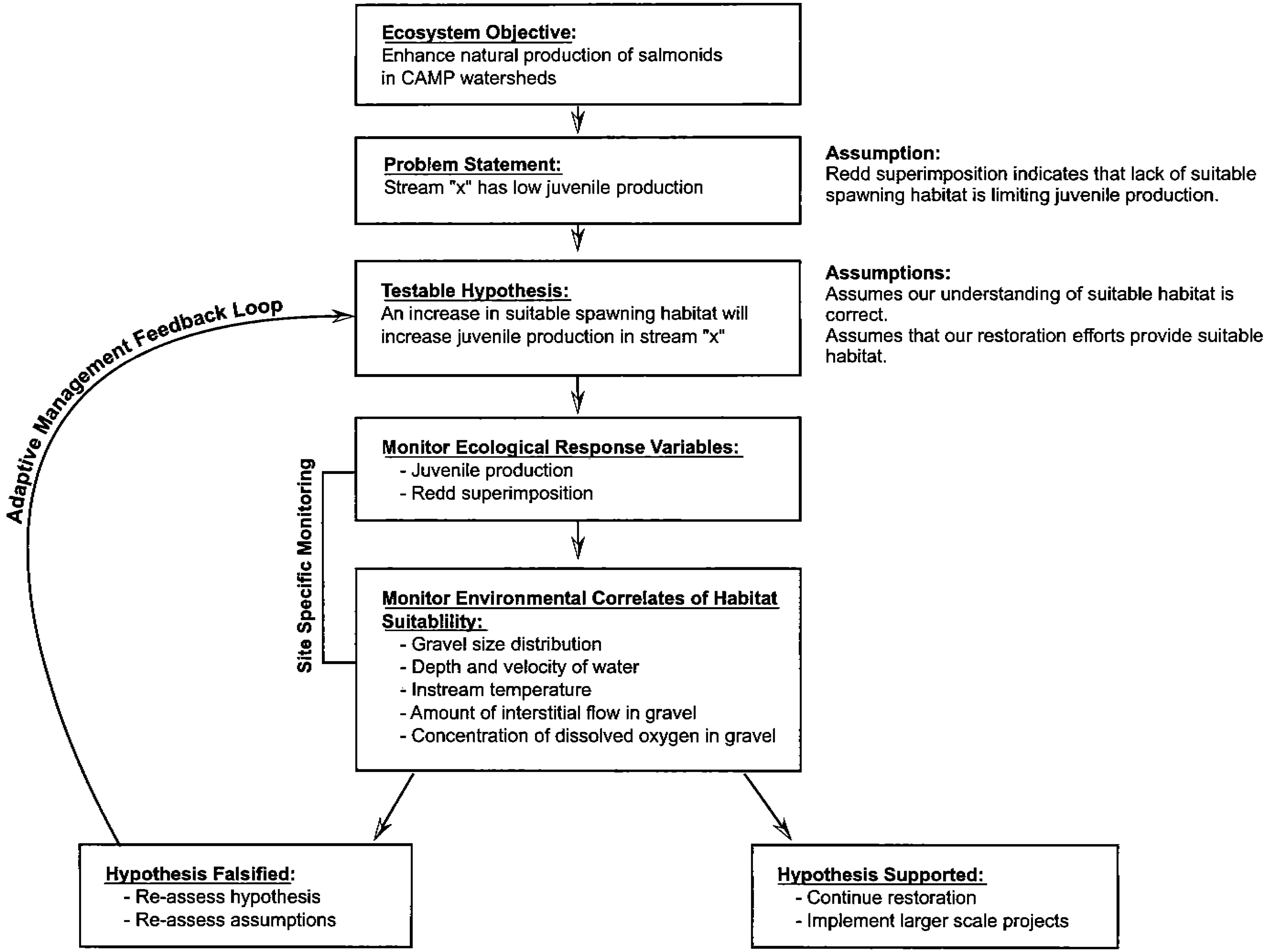

Figure 2
Conceptual Model for a Gravel Rest ration Project

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The types of physical and biological monitoring data collected will be tailored to the individual watershed and type of restoration action. Most restoration actions fall into three general categories:

- Actions that produce more habitat (e.g., barrier removal)
- Actions that improve the quality of the habitat (e.g., spawning gravels, riparian improvements, flow enhancements)
- Actions that reduce loss rates (e.g., fish screens)

Each category will have a unique set of monitored parameters, while some restoration actions will span more than one category.

Site-specific monitoring programs should measure variables that reflect changes in fish population parameters in response to the project. This usually requires monitoring prior to and following project implementation. Indirect measures may be required for some actions. For example, riparian vegetation restoration may be assessed by measuring those habitat variables affected by the action and that are critical to one or more life stages of a targeted fish species (e.g., stream temperature, prey availability, and availability of suitable rearing habitat). Because these changes may be detectable only over an extended period of time, monitoring may be required for several years following project implementation.

Table 1 is a compilation of potential restoration actions, suggested performance monitoring metrics, and monitoring techniques. The actions follow the four categories of section 3406(b) restoration actions identified in CAMP.

TABLE 1
Site-Specific Performance and Biological Monitoring

Action Category Project Type	Site-Specific Action	Performance Monitoring	Monitored Parameters	Biological Indicators
Water Management Modification	Flow augmentation	Compare to unimpaired hydrograph Achieve a standard (e.g., habitat models such as PHABSIM) Compare against a minimum flow threshold	Stream gaging Weighted usable area, depth, velocity Achieve a minimum flow	Redd counts Carcass counts Juvenile population estimates
	Temperature control through flow augmentation	Achieve a targeted temperature range Exceed a temperature threshold	In-stream temperature monitoring by reach Temperature modeling	Egg mortality in adult females Egg mortality in stream Egg to fry mortality Estimates of fry survival
	Flow fluctuation reduction	Compare against targeted ramping criteria	Stage discharge measurements Observe redd dewatering Observe juvenile stranding	Comparison of juvenile production against adults naturally spawning Juvenile production compared to number of redds Estimates of juveniles lost to stranding
Structural Modifications	Barrier removal	Access to areas upstream of barrier Changes in timing of upstream or downstream migration	Observe redds upstream of barrier that was removed Radio tagging returning adults Pit tagging outmigrating juveniles Mark/recapture	Changes in redd distribution Reduced redd superimposition Changes in adult fecundity Changes in juvenile production or survival

TABLE 1
Site-Specific Performance and Biological Monitoring

Action Category Project Type	Site-Specific Action	Performance Monitoring	Monitored Parameters	Biological Indicators
	Temperature control through facilities	Achieve a targeted temperature range Exceeds a temperature threshold	In-stream temperature monitoring by reach Temperature modeling	Egg mortality in adult females Egg mortality Egg to fry mortality Fry survival Estimates
Fish Screens	Diversion removal or modification	Entrainment Estimates	Observe entrainment Trapping Mark/recapture	Reduced adult loss Changes in juvenile production or survival
	Fish screen construction	Achieve established criteria	Approach velocities Screen opening size Sweeping velocities Bypass flows	Changes in juvenile production or survival
Habitat Restoration	Gravel addition or improvement	Increase in spawning habitat area	Weighted usable area Gravel composition Interstitial flow Dissolved oxygen	Redd counts Reduction in redd superimposition Changes in juvenile production
	Stream channel rehabilitation or modification	Achieve a pre-project design Compare reference site conditions	Channel plainform Bed scour Meso and macro habitat mapping	Redd counts Changes in juvenile production or survival

TABLE 1
Site-Specific Performance and Biological Monitoring

Action Category Project Type	Site-Specific Action	Performance Monitoring	Monitored Parameters	Biological Indicators
	Riparian habitat restoration or protection	Achieve a pre-project design Compare reference site conditions	Vegetation mapping Mammal and avian census Fish community composition Insect drop Water temperature near bank	Juvenile survival estimates Indices of juvenile health (length/weight ratios, body condition)
	Floodplain expansion	Area of inundated floodplain Frequency and duration of flooding	Aerial photos Flow/inundation patterns	Fish community composition Duration of habitat use Indices of juvenile health (length/weight ratios, body condition)
	Improved water quality	Achieve a standard	Water quality sampling In situ and laboratory bioassays for chronic or acute toxicity	Changes in adult or juvenile mortality Changes in chronic toxicity symptoms Changes in food web productivity